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(54) OPTICAL FIBRE COUPLING

(57) An optical coupling arrangement for plastics clad optical fibres is provided wherein a length of the fibre's cladding is removed at the fibre's end and a highly reflective metallic coating is substituted therefor. Fibres terminated in this manner may be spliced with conventional fibre couplers without fear of core separation caused by deformation of the plastics cladding when the fibre is under tensile stress. Two fibres having such metallic coatings on their cores may be spliced by merely placing the coated ends of the fibres in a metallic tube and soldering or gluing the ends to the tube. This approach can be used when coupling optic fibres to other optical components such as light sources and detectors.

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Fig. 1. (PRIOR ART)

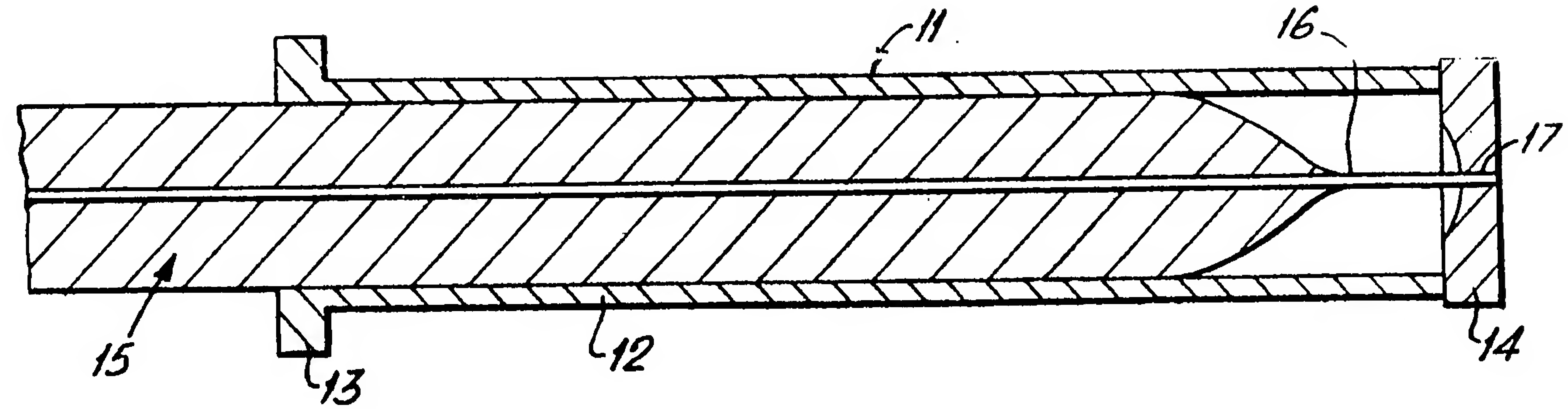
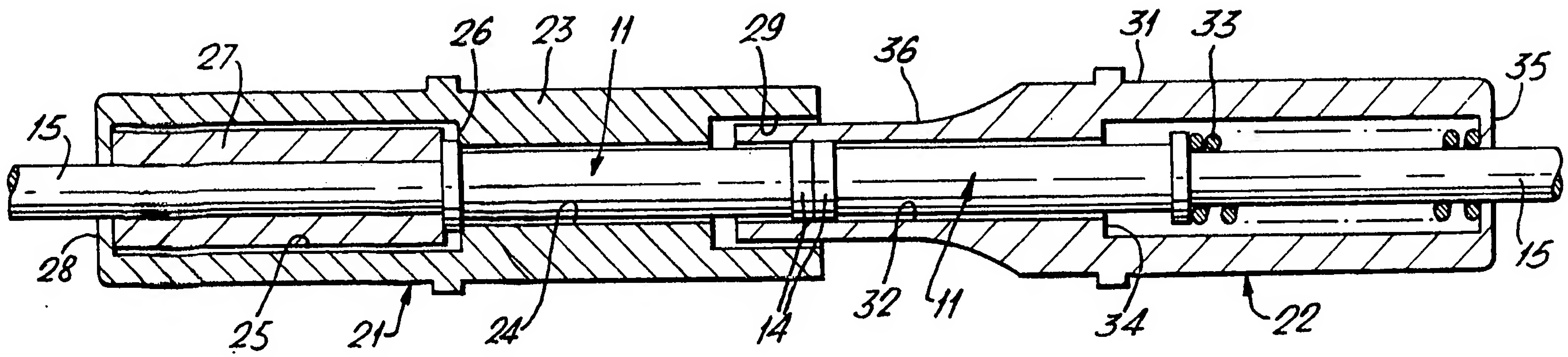


Fig. 2. (PRIOR ART)



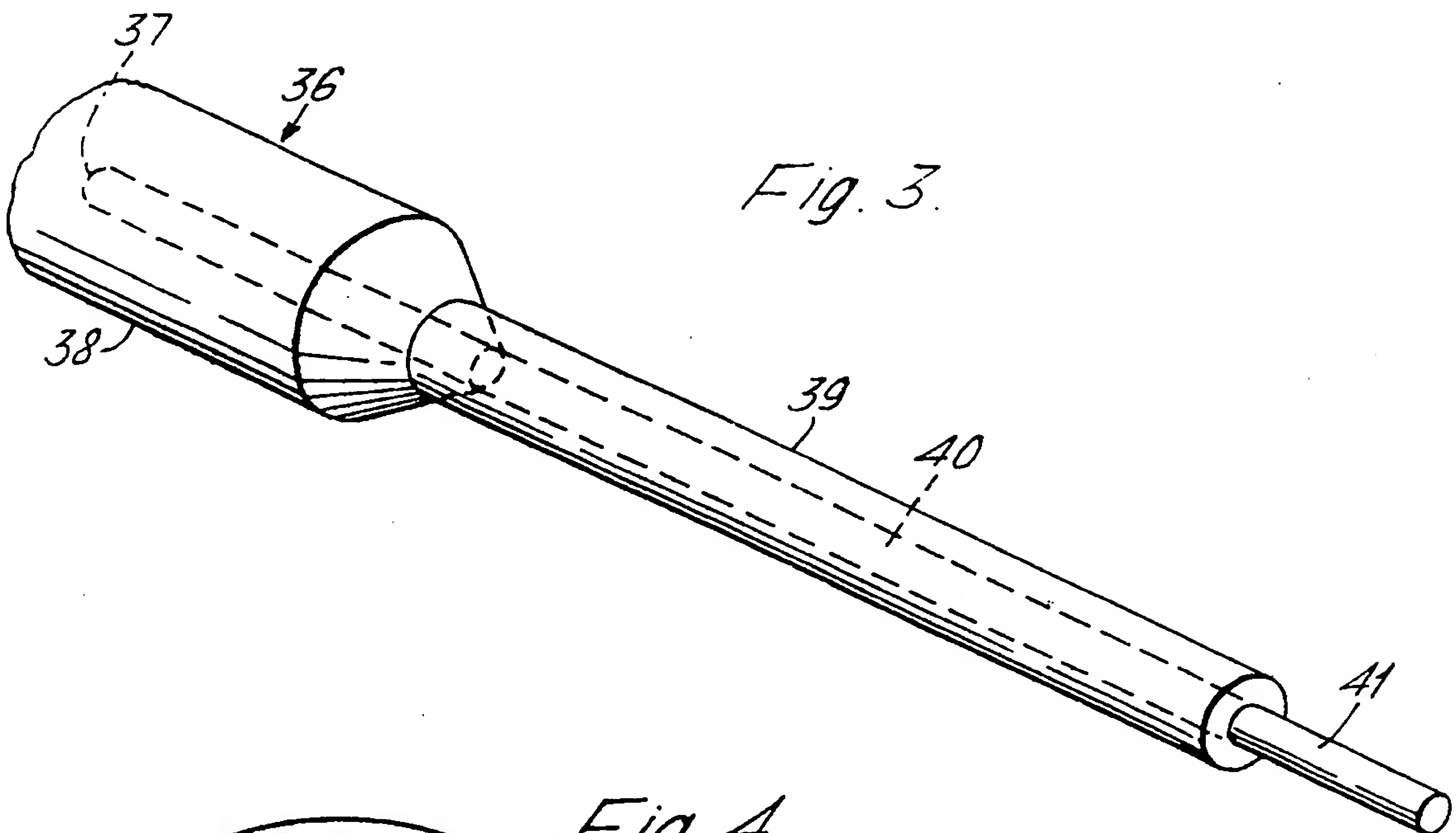
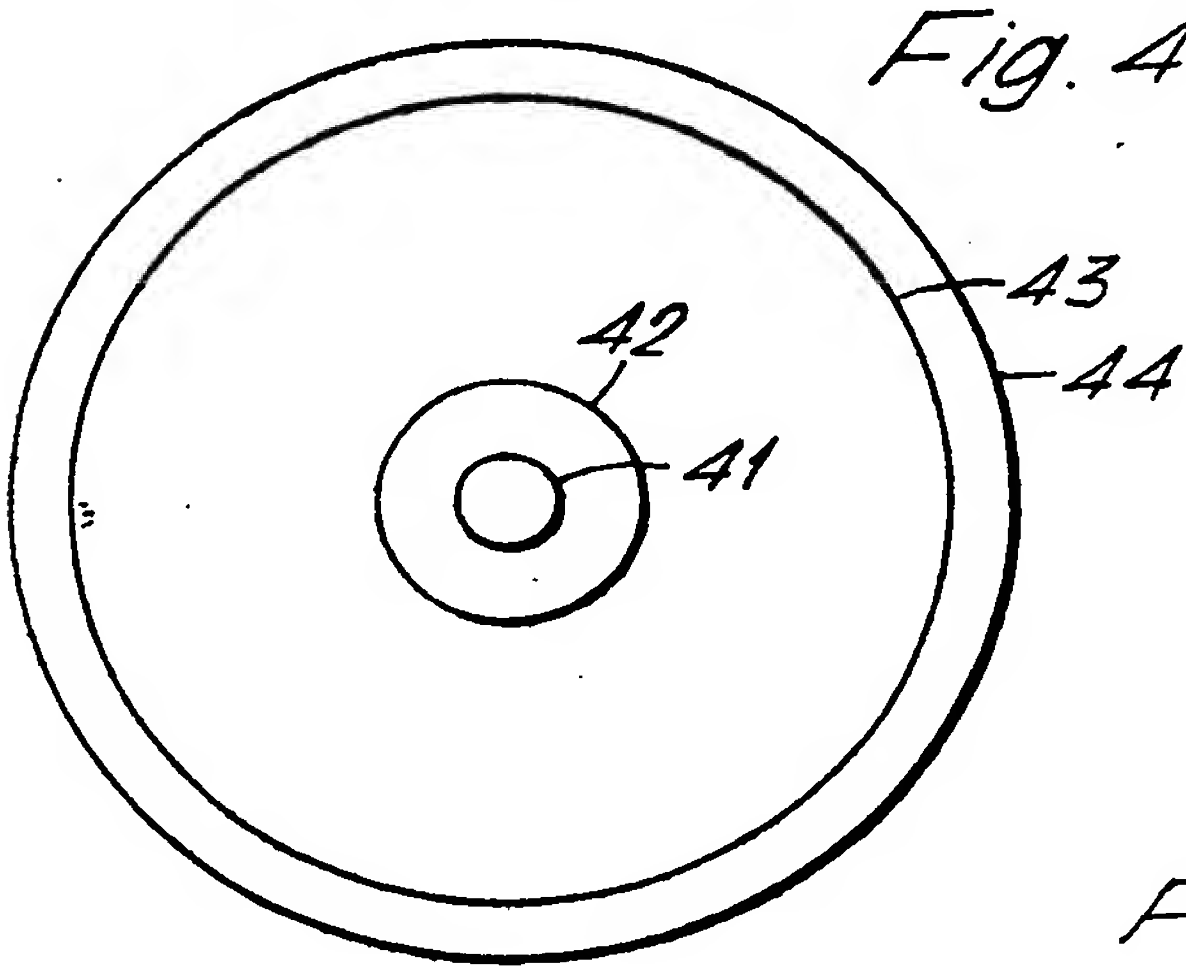


Fig. 3.

Fig. 4.



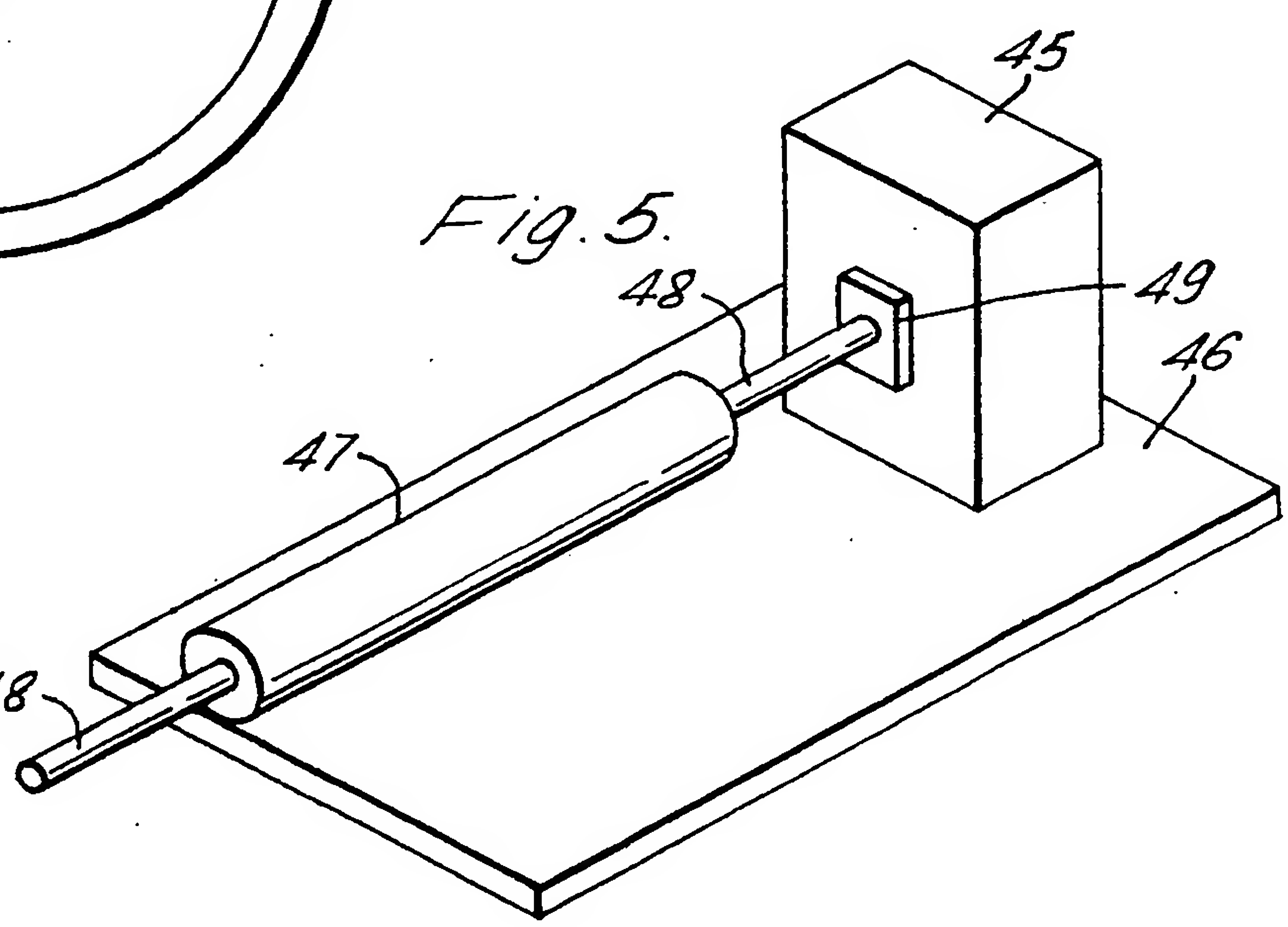


Fig. 5.

Fig. 6.

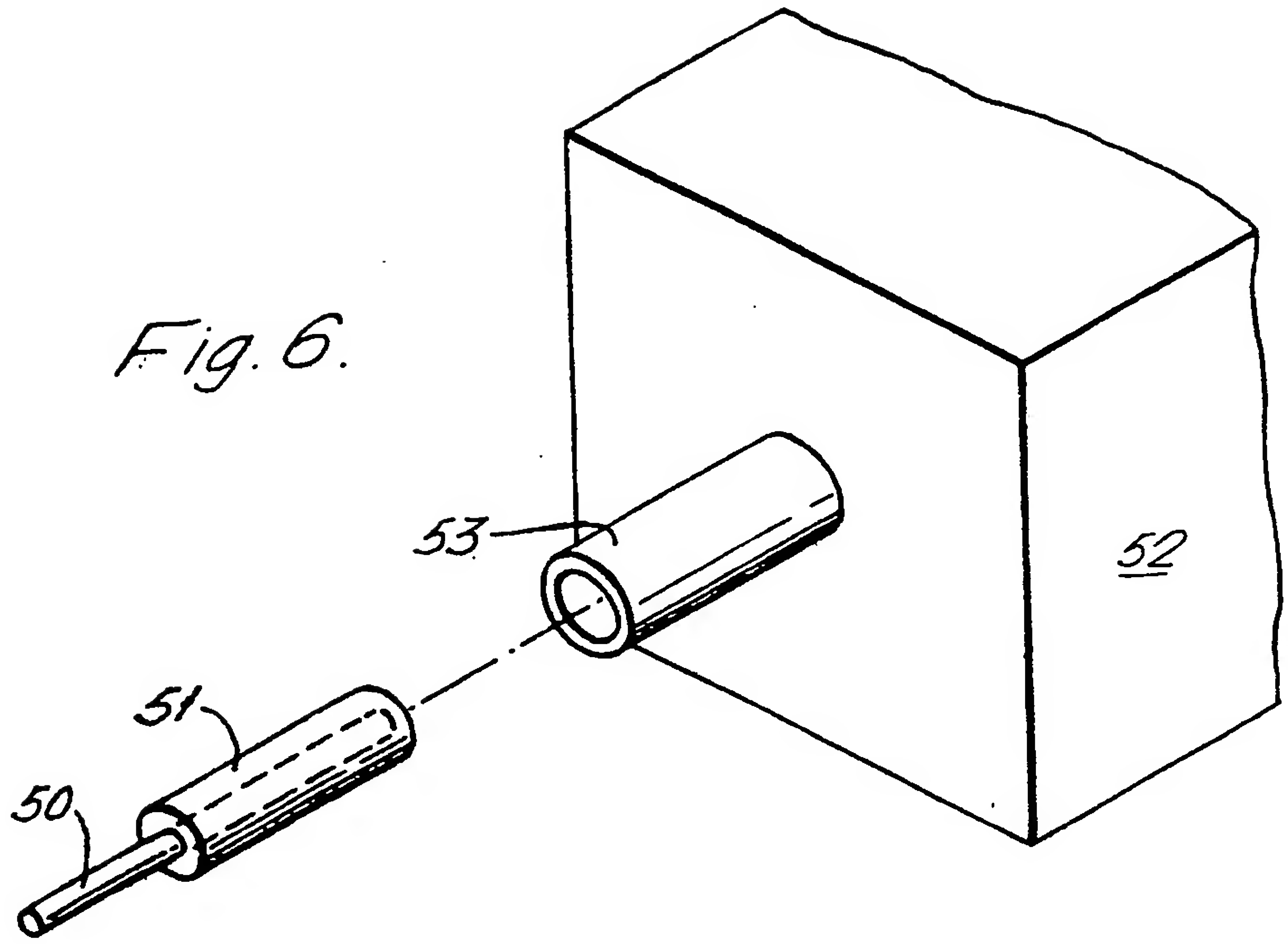


Fig. 7.

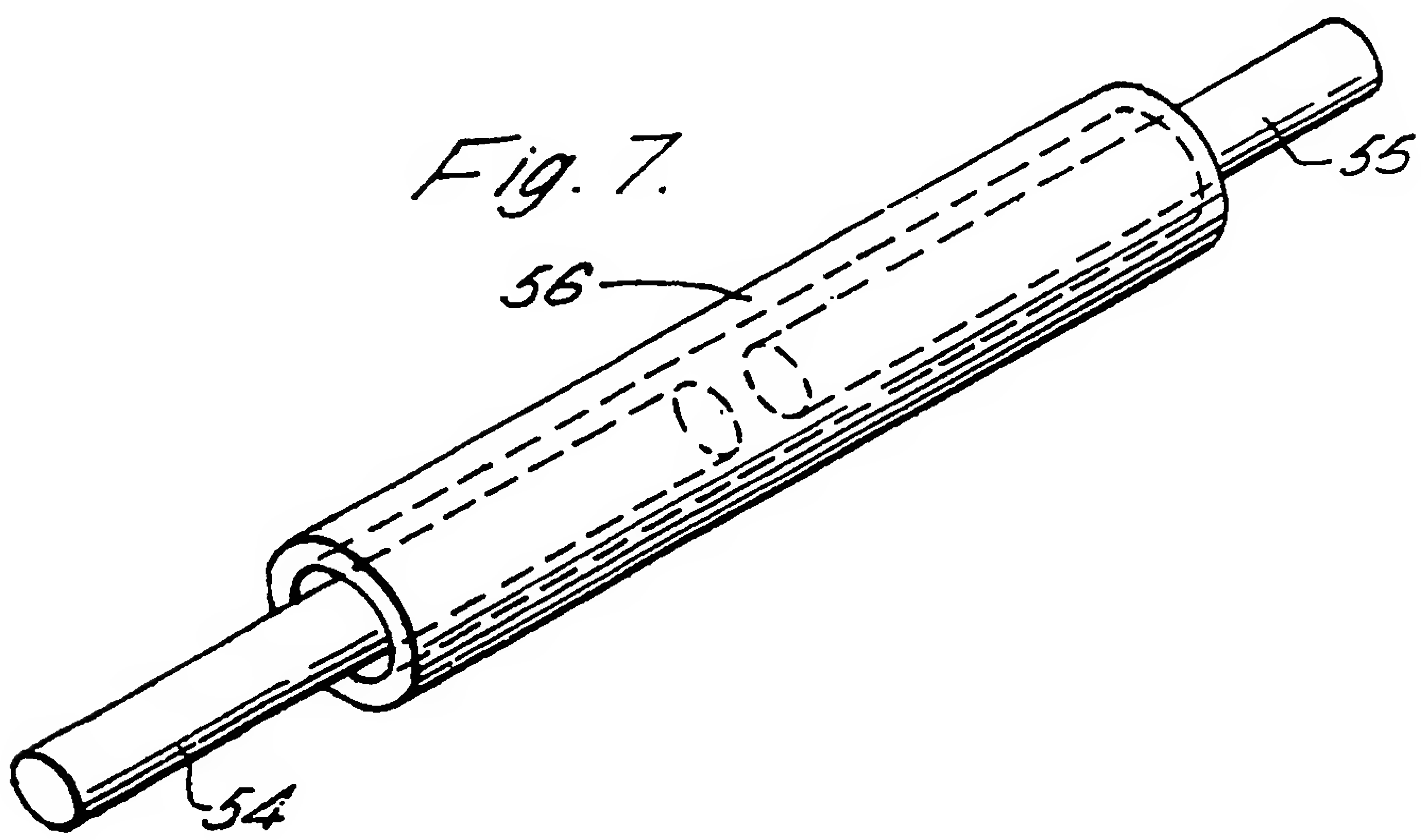
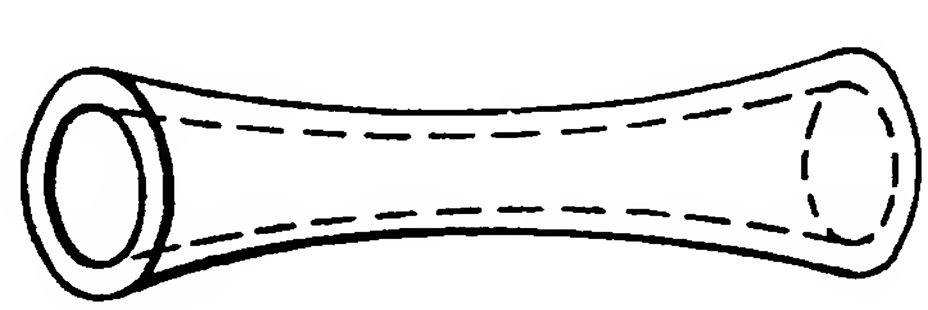


Fig. 8.



SPECIFICATION

OPTICAL FIBRE COUPLING

This invention relates generally to optical fibre couplings and, more particularly, to the coupling of plastics clad optical fibres.

The use of optical fibres for the transmission of intelligence is well established in current communications technology. In brief, by providing an optical fibre having a central core of glass and a cladding layer of glass or plastics wherein the index of refraction of the cladding layer is less than that of the core, light which enters the core at one end of the fibre will be substantially confined to the core as the light propagates down the length of the fibre. However, if optical fibre communications systems are to be widely adopted, it is essential that satisfactory means be provided for coupling optical fibres to each other, to optical sources and optical detectors, etc.

Many mechanical arrangements for coupling fibres are currently in use and perform satisfactorily when the fibres have a hard outer coating, i.e. glass cladding or hard concentric plastics cladding and/or jackets. However, since the couplers are generally subjected to mechanical stresses, the known couplers have not proved satisfactory for fibres which are clad with soft plastics material since the soft plastics material will deform under tension resulting in a separation of the optical fibre ends and a significant attenuation of the signal being transmitted.

It is an object of this invention to provide an optical fibre coupling arrangement for fibres which are clad or jacketed with soft plastics material.

According to a broad aspect of the invention there is provided a termination for an optical fibre of the type which includes a central core and an outer cladding layer wherein a length of the central core is exposed and a highly reflective metallic coating is deposited on the exposed core.

According to a further aspect of the invention, there is provided a method of terminating an optical fibre of the type which includes a core and cladding layer wherein a length of said cladding at one end of said fibre is removed to expose said core and a highly reflective metallic layer is deposited on said exposed core.

Embodiments of the invention will now be described taken in conjunction with the accompanying drawings, in which:—

Figure 1 is a vertical section taken along the axis of a ferrule used in a known optical fibre connector.

Figure 2 is a vertical section taken along the axis of a known optical fibre connector.

Figure 3 illustrates a plastics coated fibre wherein the cladding has been removed and a highly reflective metallic layer has been substituted therefor in accordance with the present invention.

Figure 4 is a transverse vertical section of an optical fibre in accordance with the present invention wherein the plastics cladding has been replaced by several concentric metallic layers.

Figures 5 and 6 illustrate techniques of coupling optical fibres coated in accordance with the present invention to optical sources and detectors using a metallic tube approach.

Figures 7 and 8 illustrate splicing techniques for optical fibres terminated in accordance with the present invention.

In Figure 1, a connector ferrule 11 comprises a tubular member 12 of circular cross section which may be manufactured from metal or cast from a plastics resin. The tubular member has a flange 13 at one end and a watch jewel 14 secured at the other end. Jewel 14 may be secured to the tubular member by an adhesive and its outer diameter is slightly greater than that of the tubular member. The inner diameter of the member 12 is of a suitable size for receiving a clad optical fibre 15 with a bared fibre core 16 positioned in a bore 17 of the jewel 14. The member 12 imparts a holding stress on the clad fibre 15, which stress is primarily absorbed by the cladding layer.

A connector assembly employing ferrules of the type shown in Figure 1 is illustrated in Figure 2. One ferrule is mounted in each of a pair of female and male connector members 21 and 22 respectively. The female member 21 comprises a tubular housing 23 having an axial bore 24 which receives the ferrule 11. The rearward portion of the housing 23 has an enlarged bore 25 defining a shoulder 26 against which the flange 13 of the ferrule 11 is held in abutment by a tubular spacer 27. The rearward end 28 of housing 23 is swaged over and secures the ferrule and the spacer in bores 24 and 25 respectively. The forward end of the housing 23 has a second enlarged bore 29 for receiving the mating male connector member 22.

The male connector member 22 is of similar construction and comprises a tubular housing 31 having an axial bore 32 which receives the ferrule 11. The bore is of such a size that the watch jewel 14 of both its own ferrule and that of the ferrule of the female connector member 21 are in interference fit or a close sliding fit in the bore 32 of connector member 22. The rearward portion of the housing 31 has an enlarged bore defining a shoulder 34 against which the flange 13 of the ferrule 11 is held in abutment by a coil spring 33 when the male connector member 22 is uncoupled from its corresponding female connector member 21. As before, the rearward end 35 of the housing 31 is swaged over and secures spring 33. The forward end of the housing 31 has an extending nose portion 36 of reduced outer diameter which slidingly fits into the enlarged bore 29 of the female connector member 21.

The two connecting members are assembled as shown in Figure 2 by inserting the nose portion 36 of the male connector member in the forward enlarged bore of the female connector member. As a connector member is pushed further into engagement the watch jewel of the female connector member enters the bore 32 of the male

connector member until it abuts the jewel 14 of the male connector member. The close fit of the two jewels in the bore 32 insures that the two fibres to be coupled are accurately aligned.

As stated previously, in the case of a plastics clad fibre, the plastics is a relatively soft material which will deform under tensile stress. Thus, even if the fibre cores are accurately aligned, tension at opposite ends of the two fibres will eventually cause the soft plastics cladding to deform resulting in a separation of the core ends and extreme attenuation of the signal.

It has been discovered that by removing the plastics cladding layer from the end of an optical fibre to be secured either to another optical fibre or to other components such as light sources of detectors and substituting therefor a highly reflective metallic coating on the fibre core, light being transmitted will still be retained in the core, and in addition, the metallic coating will supply the required strength needed to maintain the optical fibre core in proper position when coupled by means of mechanical couplers and connectors of the type described above.

For example, Figure 3 shows a plastics clad optical fibre 36 having a core 37 and a plastics cladding 38. At the rightmost end of the fibre, the cladding 38 has been removed and replaced by a layer of silver 39. This provides high reflectivity at the fibre-metal interface 40. The silver can be applied by standard electroless plating techniques such as those developed to coat mirror surfaces. That portion of the fibre core 41 which protrudes beyond the silver layer 39 enters the bore 17 of jewel 14 as described with reference to Figure 1. However, in this case, the ferrule 11 contacts no part of the fibre which still bears a plastics cladding. Only that portion of the fibre coated with silver is subjected to coupling stresses and the tendency towards core separation is reduced. In addition to silver, other materials may be used, for example gold, nickel or chromium. Nickel and chromium are of particular interest since they are materials which enhance bonding to glass surfaces.

If it is desirable to solder the metal layer to the ferrule 11, it may be necessary to protect the metal layer from the soldering materials. A second layer can be applied over the silver layer if protection from further processing steps is required. As shown in Figure 4 the core 41 may be first covered with a silver layer 42 to provide the desired reflectivity. A second barrier coating of nickel or chromium 43 could be applied to provide the required protection for the silver layer. The second layer is preferably applied using electroless plating; however, conventional plating could be used since a base layer of metal is present.

If one wishes to enhance the solderability of the fibre, a third layer 44 could be applied over layer 43. Layer 44 could consist of silver, copper, gold, tin, indium or combinations thereof. Lead-tin platings could also be used to enhance solderability. Silver, gold, and tin are particularly interesting because they may be applied electrolessly.

Aside from the problem of coupling two fibres together, commonly referred to as splicing, it is also desirable to provide a convenient and simple means of coupling fibres to other optical components, for example sources and detectors. Referring to Figure 5, a detector or source chip 49 is mounted to a chip carrier or heat sink 45. The heat sink 45 is mounted on a hybrid electronic circuitry substrate 46. A metallic tube 47 is employed to guide a fibre 48, plated as described above, to the source or detector chip 49. The metal tube 47 passes through the package wall (not shown), which holds the tube in the proper position for alignment of the fibre with the chip 49. When the fibre is in place, the plated fibre can be soldered in the tube in an inert atmosphere, or a reducing atmosphere if desired, to provide a hermetic seal.

As a further illustration, Figure 6 shows a plated coupling arrangement wherein the optical connector is actually a part of the package design. A plated optical fibre 50 is soldered into a metallic tube 51. The source or detector package 52 is provided with a metallic guide 53. The tube terminated fibre is merely inserted into the guide, and after proper positioning the tube is secured to the guide by soldering.

Using the above approach, low cross-sectional area, hermetic and solderable splices can be obtained. For example, referring to Figure 7, two plated fibres 54 and 55 may be inserted into a metallic tube 56. Sufficient clearance is provided in the tube for soldering and fillet space. The metallic tube 56 may be flared as shown in Figure 8 to reduce the possibility of breaking the fibre by sharp bends that could result without the flaring. The flared ends may be filled with a suitable filler such as bathtub caulking after soldering.

The electroless silver coating process is a modified Brashear Process wherein the solutions used are maintained preferably at a temperature of between 15°C and 18°C. The coating solution is prepared as follows: approximately 4.5 grams of A_gNO_3 are added to 60 cc distilled water and mixed. Approximately 4 cc of NH_4OH is slowly added until the solution just becomes clear. Approximately 20 cc of a solution containing two grams of KOH in 20 cc of distilled water is slowly added with agitation. This causes the solution to turn dark and opaque. Additional NH_4OH is added in an amount approximately equal to 1.5 cc until the solution is again almost clear or a light brown transparent colour. A reducing solution containing a 1 to 10 ratio by weight of purified dextrose and distilled water is then added to the coating solution in an amount approximately equal to 30 cc.

The volume of solution may be varied depending upon the amount of plating to be done.

Using the above solution, the silver deposits quickly. Some silver filaments are visible under a microscope and look spongy; however, a continuous film of silver is formed below.

In one example, a 3 foot length of 0.010″ plastics coated silica fibre was stripped of its cladding for a length of 0.5 inch at the centre of length of fibre

and plated as described above. Tests on the fibre revealed that the metal plated portion experienced a loss of less that 0.5 db per cm.

Several tensile strength tests were conducted on connectors using the invention and in each case no fibre movement was detected in the connector even up to the point at which the fibre broke.

The actual application of the silver coating by the Brashear method may be accomplished using several techniques: (1) agitation of the substrate during deposition; (2) swabbing of the substrate after initial deposition to prevent buildup of a porous silver layer; (3) stirring of the solution with a magnetic stirrer during agitation at temperatures lower than 15°C. The latter technique yielded a very consistent coating of high density silver with a minimal amount of pinholes.

The most satisfactory film was prepared when the coating was applied while subjecting the fibres and the solution to the ultrasonic vibrations of an ultrasonic cleaner.

Thus, the present invention provides a low-loss, high-strength optical fibre connector that may be used satisfactorily with plastics clad silica optical fibres.

CLAIMS

1. A termination for an optical fibre of the type that includes a central core and an outer cladding layer, including an optical fibre having a length of exposed core; and a highly reflective metallic coating deposited on said exposed core.

2. A termination as described in claim 1, wherein the metallic coating is silver, gold, nickel or chromium.

3. A termination as described in claim 1 or 2, additionally comprising a second metallic coating on said reflective coating to protect said reflective coating.

4. A termination as described in claim 3, wherein said second metallic coating is nickel or chromium.

5. A termination as described in claim 6, further including a third metallic layer on said second metallic layer.

6. A termination as described in claim 5, wherein said third metallic layer is silver, copper, gold, tin or indium.

7. A termination as described in claim 5, wherein said third metallic layer is lead-tin plating.

8. An optical fibre splice for use with optical fibres of the type that contain a central core and an outer cladding, said splice including a first optical fibre having a metallic coating on its core at a first end thereof; a second optical fibre having a metallic coating on its core at a first end thereof; and means for engaging the metallic coatings on said first and second fibres to maintain their cores in an aligned and abutting relationship.

9. An optical fibre splice as described in claim 8, wherein said means includes first and second connectors which mechanically engage said metallic coatings and means for fixedly coupling said first and second connectors.

10. An optical fibre splice as described in claim 8, wherein said means comprises a metallic tube which is soldered or glued to the metallic coatings on said first and second fibres.

11. An optical fibre splice as described in claim 8, wherein said cladding is a plastics material.

12. A method of terminating an optical fibre of the type that includes a core and cladding layer, including removing a length of said cladding layer at one end of said fibre to expose said core; and depositing on said exposed core a highly reflective metallic layer.

13. A method of terminating an optical fibre as described in claim 12, wherein said metallic layer is silver.

14. A method of terminating an optical fibre as described in claim 12, wherein said metallic layer is gold, nickel or chromium.

15. A method of terminating an optical fibre as described in claim 12, further including the step of depositing a second metallic layer on said reflective metallic layer to protect said reflective metallic layer.

16. A method of terminating an optical fibre as described in claim 15, wherein said second metallic layer is nickel or chromium.

17. A method of terminating an optical fibre as described in claim 15, further including the step of depositing a third metallic layer on said second metallic layer to enhance solderability.

18. A method as described in claim 12, wherein the metallic layer is deposited electrolessly by dipping the core in a plating solution.

19. A method as described in claim 18, wherein the core and plating solution are subjected to ultrasonic vibrations during plating.

20. An optical fibre splice substantially as described with reference to Figures 3, 7 and 8 of the accompanying drawings.

21. An optical fibre termination substantially as described with reference to Figures 3, 4, 5, 6 and 7 of the accompanying drawings.

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